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In Memoriam Professor Ky Fan (1914–2010)

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Professor Ky Fan passed away on March 22, 2010 at the age of 95 in Santa Barbara, CA. Born in Hangzhou, China on September 19, 1914, Fan would go on to pursue a career in mathematics that spanned more than 70 years. His impact on the field, however, cannot be adequately described simply by listing his many publications and public accolades. Of equal importance is his seemingly prescient ability to identify key problems in mathematics, sometimes decades before others even began to address these same issues. Fan also took great pride in mentoring students, pushing them to excel while instilling in them a love of mathematics.

I first became aware of Fan when I was a sophomore at National Taiwan University. One of the textbooks used in a class I took on Advanced Geometry was Fan's translation of Einfuhrung in die Analytische Geometric and Algebra ("Analytical Geometry and Algebra") by O. Schreier and E. Sperner. Strange as it may sound, his translation of this text, completed while he was a junior in college at Peking University, inspired me to leave Taiwan, my family, and friends to immigrate to a far-off place called Notre Dame. There I would begin five unforgettable years with Fan pursuing a Ph.D. in mathematics.

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The first year I was at Notre Dame, I remember vividly a course he taught on General Topology. I was struck by how beautifully organized the course was. Fan's lectures were riveting, not only because of the intensity and clarity with which Fan delivered his lectures, but also because of the distinct possibility that we would be called upon by name to answer questions during class. It quickly became apparent that Fan did not tolerate imprecise or irrelevant answers, and had absolutely no compunctions letting the class know his opinion of a given answer. Fortunately for myself, possibly because of my broken English, I was never called upon to answer any questions. Fan's class was extraordinarily rich in content, and covered, in one year, areas from set theory to uniform spaces. The class was relieved when Fan gave everyone an entire weekend to complete the final exam. But despite the extra time, none of us were able to solve one particularly difficult problem. Naturally, we found out later that there was as yet no solution, but Fan expected us to propose some reasonable ways to attack it.

It is no wonder, perhaps, that as a teacher, his students both idolized and were afraid of him. But as a mentor, he was always exceedingly kind, and went out of his way to help his students. In the summer of 1960, I and four other Ph.D. candidates followed him from Notre Dame to Wayne State University in Detroit. Dr. Fan and his wife Yu-Fen took me in and I stayed with them the entire summer at their home in Dearborn, Michigan. The Fans made me feel extremely welcome, and I almost felt as if I was home with my parents in Taiwan. The Fans themselves lived as though they were in China. Fan worked all night until daybreak, while Yu-Fen prepared Chinese meals for us. Each day, Fan would drive the two of us to campus. He hated the long commute between home and school, but I quickly learned that mathematics should not be a topic of discussion to pass the time. Fan had a disconcerting and rather alarming tendency to focus his attention on the mathematical problems being discussed rather than on the road in front. But, as he might say, only if the problem under discussion was particularly interesting.

Fan's style of training students was also unusual. As I later appreciated, most Ph.D. students are given relatively narrow topics on problems that are in the field of expertise of the mentor. Typically they are given papers published by the mentor and the general direction of study is roughly defined for them. As far as I am aware, Fan has never followed this format. Instead, Fan would find a problem he found interesting, no matter what the area or his expertise, and assign it to the student. For example, for my thesis, I studied certain topological properties of infinite dimensional normed linear spaces. The main question I was to address is in what kind of infinite dimensional normed linear spaces, the unit sphere is homeomorphic to the unit ball of the space. As he demonstrated throughout his career, Fan identified this as a central question in topology long before it was recognized as such by others. Some 10–15 years later, in the 1970's, this same question attracted the attention of many topologists, who eventually solved the problem using topological rather than analytical approaches.

Fan's interests were so broad that later, when I was looking for a job, I had a difficult time answering the question: "what area is your advisor in?" Fan's papers spanned the gamut of theoretical mathematics, and studied problems in analysis, topology, and algebra. At the same time, he was always very modest, and never, ever, suggested that I look up any of his old papers. In the early 1970's, I was preparing a paper to celebrate his 60th birthday. At that time, I was interested in the geometry of Banach spaces, and found in a paper by K. Fan and I. Glicksberg (Fully convex normed linear spaces, Proc. Natl. Acad. Sci. USA 41 (1955) 947–955) their introduction of a class of normed linear spaces that extend and preserve important properties of uniformly convex spaces. In another paper, (K. Fan and I.Glicksberg, Some geometric and topological properties on the unit sphere in a normed linear spaces, Duke Math. J. 25 (1958) 553–568), they studied a list of 16 properties of the unit sphere of a normed linear space including a concept that later was called point of sequentially continuity. They also introduced a new geometric concept that later was called denting points. He told me that he got the idea of denting points by observing the changing shapes of the moon. He would call it a moon point. This paper was completely overlooked by people working in Banach space theory at the time. In the 1980's, denting points became the main concept in the study of Radon–Nikodym property in Banach space theory. He was very happy to know that I described the relationships between denting points, extreme points and points of continuity. My study on fully convex spaces, based on Fan's papers published some 25 years before, helped make this an active area of research in Banach spaces in the 1980's. Fan had once again been able to define key questions in a field years before others recognized the problem.

In 1977, I took a year of leave to become a visiting Professor at UC Santa Barbara. Professor and Mrs. Fan welcome my family and I, and we had many happy visits together at their beautiful home overlooking the ocean. Professor Fan was very proud of the trees that he planted on the hill. At that time, I was interested in studying minimax theorems. Fan once again referred me to papers by people other than himself. I quickly discovered, however, that he had proved the first nonlinear minimax theorems (K. Fan, Minimax theorems, Proc. Natl. Acad. Sci. USA 39 (1953) 42–47) and introduced the concept of convexity/concavity in sets without linear structure. In the late 1970's, various abstract concepts of convexity were introduced by H. Konig and S. Simmons and others. Always the Chinese Scholar and a gentleman, he was very happy that I had a role developing of nonlinear minimax theorems, and never touted the fact that he had produced some of the first research in this area.

In 1984, Stephen Simmons and I organized a conference to celebrate his 70th birthday and his impending retirement from UC Santa Barbara. Mathematicians from four continents participated in the conference, and were drawn based upon their interest in Fan's work. Presentations at the meeting covered a staggering array of mathematics, from abstract analysis to applied mathematical economics. The conference was a living testament to the range and impact of Fan's studies in mathematics. Stephen and I had a very difficult time choosing a title for the Proceedings. We finally settled on the broadly inclusive and yet appropriately vague title "Nonlinear and Convex Analysis, Proceedings in Honor of Ky Fan".

Professor Fan continued to publish even into his eighties. Despite being confined to a wheelchair and also increasingly hard of hearing, he nevertheless continued to study and take joy in the beauty of mathematics. His love and dedication to mathematics is a model for all of us, and his contributions will be studied for generations to come. We will miss him.

For more information on Ky Fan's background, his list of publications up to 1992, a list of his Ph.D. students and his talk as the featured speaker at the Auburn Conference on Directions in Matrix Theory, please see Linear Algebra and its Applications 162–164(1–2) (1992) 1–22. For more information on his background and his role as a mentor and teacher, please see my article "EVERY WAKING MOMENT, Ky Fan (1914–2010)" in Notices of the American Mathematical Society.